UL 44

STANDARD FOR SAFETY

Thermoset-Insulated Wires and Cables

UL Standard for Safety for Thermoset-Insulated Wires and Cables, UL 44

Nineteenth Edition, Dated January 9, 2018

Summary of Topics

This revision of ANSI/UL 44 dated May 14, 2021 includes a Modification of Requirements for Conductor Stranding Marking on Product; 6.1.5 and Table 49

Text that has been changed in any manner or impacted by UL's electronic publishing system is marked with a vertical line in the margin.

The new and revised requirements are substantially in accordance with Proposal(s) on this subject dated October 9, 2020.

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Sixth Edition

CSA Group
CSA C22.2 No. 38-18
Eleventh Edition

Underwriters Laboratories Inc.
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Thermoset-Insulated Wires and Cables

January 9, 2018

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Approved American National Standard

ANSI/UL 44-2021

Commitment for Amendments

This standard is issued jointly by the Association of Standardization and Certification (ANCE), the Canadian Standards Association (operating as “CSA Group”), and Underwriters Laboratories Inc. (UL). Comments or proposals for revisions on any part of the standard may be submitted to ANCE, CSA Group, or UL at anytime. Revisions to this standard will be made only after processing according to the standards development procedures of ANCE, CSA Group, and UL. CSA Group and UL will issue revisions to this standard by means of a new edition or revised or additional pages bearing their date of issue. ANCE will incorporate the same revisions into a new edition of the standard bearing the same date of issue as the CSA Group and UL pages.

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This Standard is subject to review within five years from the date of publication, and suggestions for its improvement will be referred to the appropriate committee. To submit a proposal for change, please send the following information to inquiries@csagroup. org and include "Proposal for change" in the subject line: Standard designation (number); relevant clause, table, and/or figure number; wording of the proposed change; and rationale for the change.

This ANSI/UL Standard for Safety consists of the Nineteenth Edition including revisions through May 14, 2021. The most recent designation of ANSI/UL 44 as an American National Standard (ANSI) occurred on May 14, 2021. ANSI approval for a standard does not include the Cover Page, Transmittal Pages, Title Page (front and back), or the Preface.

The Department of Defense (DoD) has adopted UL 44 on April 5, 1985. The publication of revised pages or a new edition of this Standard will not invalidate the DoD adoption.

Comments or proposals for revisions on any part of the Standard may be submitted to UL at any time. Proposals should be submitted via a Proposal Request in UL's On-Line Collaborative Standards Development System (CSDS) at https://csds.ul.com.

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PREFACE

This is the harmonized ANCE, CSA Group, and UL standard for Thermoset-Insulated Wires and Cables. It is the Sixth edition of NMX-J-451-ANCE, the Eleventh edition of CSA C22.2 No. 38, and the Nineteenth edition of UL 44. This edition of NMX-J-451-ANCE supersedes the previous edition published in March 28, 2014. This edition of CSA C22.2 No. 38 supersedes the previous edition published in March 28, 2014. This edition of UL 44 supersedes the previous edition published in March 28, 2014. This harmonized standard has been jointly revised on May 14, 2021. For this purpose, CSA Group and UL are issuing revision pages dated May 14, 2021, and ANCE is issuing a new edition dated May 14, 2021.

This harmonized standard was prepared by the Association of Standardization and Certification, (ANCE), CSA Group and Underwriters Laboratories Inc. (UL). The efforts and support of the Technical Harmonization Committee for Electrical Wires and Cables, of the Council on the Harmonization of Electrotechnical Standards of the Nations of the Americas (CANENA), are gratefully acknowledged.

This standard is considered suitable for use for conformity assessment within the stated scope of the standard.

The present Mexican Standard was developed by the CT 20 Conductores from the Comite de Normalizacion de la Asociacion de Normalizacion y Certificacion, A.C., CONANCE, with the collaboration of the SC 20B Conductores para Baja Tensión.

This standard was reviewed by the CSA Integrated Committee on Fixed Installation Wires and Cables, under the jurisdiction of the CSA Technical Committee on Wiring Products and the CSA Strategic Steering Committee on Requirements for Electrical Safety, and has been formally approved by the CSA Technical Committee. This standard has been developed in compliance with Standards Council of Canada requirements for National Standards of Canada. It has been published as a National Standard of Canada by CSA Group.

This standard has been approved by the American National Standards Institute (ANSI) as an American National Standard.

Application of Standard

Where reference is made to a specific number of samples to be tested, the specified number is to be considered a minimum quantity.

Note: Although the intended primary application of this standard is stated in its scope, it is important to note that it remains the responsibility of the users of the standard to judge its suitability for their particular purpose.

Level of Harmonization

This standard uses the IEC format but is not based on, nor is it considered equivalent to, an IEC standard.

This standard provides requirements for insulated wires and cables for use in accordance with the electrical installation codes of Canada, Mexico, and the United States. At present there is no IEC standard for wires and cables for use in accordance with these codes. Therefore, this standard does not employ any IEC standard for base requirements.

This standard is published as an equivalent standard for ANCE, CSA Group and UL.

An equivalent standard is a standard that is substantially the same in technical content, except as follows: Technical national differences are allowed for codes and governmental regulations as well as those recognized as being in accordance with NAFTA Article 905, for example, because of fundamental climatic,

geographical, technological, or infrastructural factors, scientific justification, or the level of protection that the country considers appropriate. Presentation is word for word except for editorial changes.

Interpretations

The interpretation by the standards development organization of an identical or equivalent standard is based on the literal text to determine compliance with the standard in accordance with the procedural rules of the standards development organization. If more than one interpretation of the literal text has been identified, a revision is to be proposed as soon as possible to each of the standards development organizations to more accurately reflect the intent.

Thermoset-Insulated Wires and Cables

1 Scope

1.1 This Standard specifies the requirements for single-conductor and multiple-conductor thermoset-insulated wires and cables rated 600 V, 1000 V, 2000 V, and 5000 V, for use in accordance with the rules of the Canadian Electrical Code, Part I, CSA C22.1, in Canada, Standard for Electrical Installations, NOM-001-SEDE, in Mexico, and the National Electrical Code (NEC), NFPA 70, in the United States of America.

See Annex A for the complete list of types and voltage ratings covered by this Standard and the specific electrical codes for which they are intended, and Annex B for a summary of construction and test requirements for these types.

1.2 Table 1 provides a summary of the maximum conductor temperature, voltage ratings, and the number of insulated conductors for the types to which this Standard applies.

1.3 This Standard also specifies the requirements for submersible pump cables, with or without jackets, in Deep Well Submersible Water-Pump Cable, Section 7. No type-letter designations are assigned to these cables.

1.4 Products within this Standard might have applications not covered by the electrical codes listed in 1.1.

2 General

2.1 Units of measure

Values stated without parentheses are the requirement. Values in parentheses are explanatory or approximate information.

2.2 Reference publications

Where reference is made to any Standards, such reference shall be considered to refer to the latest editions and revisions thereto available at the time of printing, unless otherwise specified.

Secretary of Energy

NOM-001-SEDE,
Standard for Electrical Installations

ANCE Standards

NMX-J-008-ANCE,
Tinned Soft or Annealed Copper Wire for Electrical Purposes – Specifications

NMX-J-012-ANCE,
Wires and Cables – Concentric Lay Stranded Copper Conductors for Electrical Purposes – Specifications

NMX-J-013-ANCE,
Wires and Cables – Rope Lay Stranded Copper Conductors Having Concentric Stranded Members for Electrical Purposes – Specifications

NMX-J-014-ANCE,
Wires and Cables – Rope Lay Stranded Copper Conductors Having Bunch Stranded Members for Electrical Purposes – Specifications

NMX-J-032-ANCE,
Wires and Cables – Concentric Lay Stranded Aluminum Cable for Electrical Purposes – Specifications

NMX-J-036-ANCE,
Soft or Annealed Copper Wire for Electrical Purposes – Specifications

NMX-J-040-ANCE,
Wires and Cables – Determination of the Moisture Absorption in Insulations of Electrical Conductors – Test Method

NMX-J-066-ANCE,
Determination of Diameters of Electrical Conductors – Test Method

NMX-J-093-ANCE,
Wires and Cables – Determination of the Resistance to Fire Propagation on Electrical Conductors – Test Method

NMX-J-177-ANCE,
Wires and Cables – Determination of Thickness in Semiconductive Shielding, Insulations, and Jackets of Electrical Conductors – Test Method

NMX-J-178-ANCE,
Wires and Cables – Ultimate Strength and Elongation of Insulation, Semiconducting Shields and Jackets of Electrical Conductors – Test Method

NMX-J-186-ANCE,
Wires and Cables – Accelerated Aging in Forced Convection Oven of Semiconducting Shields, Insulations and Jackets of Electrical Conductors – Test Method

NMX-J-190-ANCE,
Wires and Cables – Thermal Shock Resistance of PVC Insulations and Protective Coverings of Electrical Conductors – Test Method

NMX-J-191-ANCE,
Wires and Cables – Heat Distortion of Insulations and Protective Coverings of Electrical Conductors – Test Method

NMX-J-192-ANCE,
Electrical Products – Wires and Cables – Flame Test on Electrical Wires – Test Method

NMX-J-193-ANCE,
Wires and Cables – Cold Bend of Insulation and Non-Metallic Protective Jackets Used on Insulated Wire and Cable – Test Method

NMX-J-194-ANCE,
Wires and Cables – Oil Immersion Aging for Insulations and Jackets of Electrical Conductors – Test Method

NMX-J-212-ANCE,

Wires and Cables – Electrical Resistance, Resistivity and Conductivity – Test Method

NMX-J-293-ANCE,
Wires and Cables – Alternative Current and Direct Current Dielectric Voltage Withstand – Test Method

NMX-J-294-ANCE,
Wires and Cables – Insulation Resistance – Test Method

NMX-J-312-ANCE,
Wires and Cables – Tensile Strength and Elongation at Break of Electrical Conductors – Test Method

NMX-J-432-ANCE,
Wires and Cables – Determination of Hot Elongation and Permanent Deformation (Hot Creep), to Ethylene Propylene Rubber and Cross-Linked Polyethylene Insulations – Test Method

NMX-J-472-ANCE,
Electrical Products – Wires and Cables – Determination of the Amount of Halogen Acid Gas Evolved During the Controlled Combustion of Polymeric Materials Taken from Electrical Cables – Test Method

NMX-J-473-ANCE,
Wires and Cables – Spark Test – Test Method

NMX-J-474-ANCE,
Electrical Products – Wires and Cables – Determination of Specific Optical Density of Smoke Generated by Electrical Wires and Cables – Test Method

NMX-J-498-ANCE,
Wires and Cables – Vertical Tray Flame

NMX-J-532-ANCE,
Electrical Products – Wires and Cables – AA-8000 Series Aluminum Alloy Wires – Specifications

NMX-J-533-ANCE,
Wires and Cables – AA-8000 Series Aluminum Alloy Cables – Specifications

NMX-J-553-ANCE,
Wires and Cables – Weather Resistance of Insulation or Jacket of Electrical Conductors – Test Method

NMX-J-556-ANCE,
Wire and Cable Test Methods

CSA Group Standards

C22.1-15,
Canadian Electrical Code, Part I

CAN/CSA-C22.2 No. 0,
General Requirements – Canadian Electrical Code, Part II

C22.2 No. 96,
Portable Power Cables

C22.2 No. 245,

Marine Shipboard Cable

CAN/CSA C22.2 No. 2556,
Wire and Cable Test Methods

UL Standards

UL 1309
Marine Shipboard Cable

UL 2556
Wire and Cable Test Methods

UL 2806
Outline of Investigation for Heavy Duty Flexible Power Cable

ASTM (American Society for Testing and Materials)

B3-01(2013)
Standard Specification for Soft or Annealed Copper Wire

B8-11
Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

B33-10
Standard Specification for Tinned-Coated Soft or Annealed Copper Wire for Electrical Purposes

B172-10
Standard Specification for Rope-Lay-Stranded Copper Conductors Having Bunch-Stranded Members, for Electrical Conductors

B173-10
Standard Specification for Rope-Lay-Stranded Copper Conductors Having Concentric-Stranded Members, for Electrical Conductors

B298-07
Standard Specification for Silver-Coated Soft or Annealed Copper Wire

B355-11
Standard Specification for Nickel-Coated Soft or Annealed Copper Wire

B801-07(2012)
Standard Specification for Concentric-Lay-Stranded Conductors of 8000 Series Aluminum Alloy for Subsequent Covering or Insulation

B835-04(2009)
Standard Specification for Compact Round Stranded Copper Conductors Using Single Input Wire Construction

B836-00(2011)
Standard Specification for Compact Round Stranded Aluminum Conductors Using Single Input Wire Construction

B901-04(2011)
Standard Specification for Compressed Round Stranded Aluminum Conductors Using Single Input Wire Construction

B902-13
Standard Specification for Compressed Round Stranded Copper Conductors, Hard, Medium-Hard, or Soft Using Single Input Wire Construction

D2663-08
Standard Test Methods for Carbon Black – Dispersion in Rubber

IEC (International Electrotechnical Commission)

IEC 60228 (2004-11)
Conductors of insulated cables

National Research Council Canada

National Building Code of Canada

NFPA (National Fire Protection Association)

NFPA 70-2014
National Electrical Code

2.3 General requirements

In Canada, general requirements applicable to this Standard are given in CAN/CSA-C22.2 No. 0.

3 Definitions

3.1 The following definitions apply in this Standard:

Composite insulation system – a multiple-layer system of materials that fulfills the requirements for both electrical and mechanical integrity of the cable or wire.

CP – a thermoset compound whose characteristic constituent is chlorosulfonated polyethylene.

CPE – a thermoset compound whose characteristic constituent is chlorinated polyethylene.

EPCV – a thermoset compound whose characteristic constituent is a co-vulcanizate of ethylene and propylene with polyethylene.

EP – a thermoset compound whose characteristic constituent is a copolymer of ethylene and propylene, or a terpolymer of ethylene, propylene, and a small amount of nonconjugated diene, or a blend of both.

Equipment-grounding conductor – a conductor that is defined in the *National Electrical Code* and the *Standard for Electrical Installations* as "Grounding Conductor, Equipment", and defined in the *Canadian Electrical Code*, Part I, as "Bonding conductor".

NBR/PVC – a thermoset compound whose characteristic constituents are acrylonitrile butadiene rubber and polyvinyl chloride.

Neoprene – a thermoset compound whose characteristic constituent is polychloroprene.

SBR/IIR/NR – designates a thermoset compound whose characteristic constituent is SBR (styrene and butadiene copolymer), IIR (butyl rubber), blends of SBR and IIR, or blends of SBR and/or IIR with NR (natural rubber).

Silicone (rubber) – a thermoset compound whose basic constituent is poly-organo-siloxane.

Thermoplastic – a jacket material that repeatedly can be softened by heating and hardened by cooling through a temperature range characteristic of the material, and that in the softened state can be shaped through the application of force.

Thermoset – an insulating or jacketing polymeric material which, when cross-linked, will not flow on subsequent heating. Cross-linking is accomplished either chemically or by irradiation.

XL – a thermoset compound whose characteristic constituent is cross-linked polyethylene, cross-linked polyvinyl chloride, cross-linked ethylene vinyl acetate, cross-linked ethylene ethyl acrylate, or blends thereof.

XL Filled– an XL material in which the mass fraction of materials other than the characteristic constituent polymer(s) is 10 percent or greater. These materials include carbon black, inorganic minerals, and solid flame retardants.

XL Unfilled – an XL material in which the mass fraction of materials other than the characteristic constituent polymer(s) is less than 10 percent. These materials include carbon black, inorganic minerals, and solid flame retardants.

4 Construction

4.1 Conductors

4.1.1 General

Circuit and equipment-grounding conductors shall be of copper, aluminum, or copper-clad aluminum.

4.1.2 Aluminum conductors

4.1.2.1 Aluminum conductors shall only be of aluminum conductor material (ACM), AA 8000 series alloy.

Annex C provides the chemical composition of recognized aluminum alloy conductor materials.

4.1.2.2 In Mexico, thermoset-insulated aluminum conductors are limited to sizes 13.3 mm^2 (6 AWG) and larger in accordance with NOM-001-SEDE, *Standard for Electrical Installations*.

4.1.3 Copper-clad aluminum conductors

In the United States, the requirements of Annex D shall apply to solid conductors or the individual wires of stranded conductors prior to stranding.

In Canada and Mexico, copper-clad aluminum conductors shall not be used in thermoset-insulated wires and cables.

4.1.4 Copper conductors

4.1.4.1 General

The requirements of 4.1.4.2 or 4.1.4.3 shall apply to solid conductors or the individual wires of stranded conductors prior to stranding. If the insulation adjacent to a copper conductor is of a material that corrodes unprotected copper, as determined by the requirement in 5.7, or if a protective separator in compliance with 4.1.8 is not provided, the solid conductor and each of the individual strands of a stranded conductor shall be separately covered with a coating as described in 4.1.4.2.

4.1.4.2 Coated copper conductors

4.1.4.2.1 Each tin-coated conductor shall comply with the requirements of ASTM B33 or NMX-J-008-ANCE; a nickel-coated wire shall comply with ASTM B355, and a silver-coated wire shall comply with ASTM B298. Conductors coated with other metals or alloys shall be subjected to special investigation.

Note: *In Mexico, the use of ASTM B355 is recommended for nickel-coated wire, and the use of ASTM B298 is recommended for silver-coated wire.*

4.1.4.2.2 A metal coating, when not required, is appropriate for use on solid or individual wires (strands) or selected wires, such as the outer layer of wires of a stranded conductor. The metal coating when used shall comply with 4.1.4.1.

4.1.4.3 Uncoated copper conductors

Each wire in an uncoated copper conductor shall comply with the requirements of ASTM B3 or NMX-J-036-ANCE.

4.1.5 Sizes and stranding

4.1.5.1 Sizes

4.1.5.1.1 Conductors shall be of a size and assembly indicated for the finished wire type in Table 2.

4.1.5.1.2 Copper strands smaller than 0.0127 mm^2 (36 AWG) and aluminum strands smaller than 0.25 mm^2 (24 AWG) shall not be used. A compact stranded conductor shall not be segmented. Aluminum conductors produced with greater strand counts than Class D shall have the same strand size and strand count as the equivalent stranded copper conductors.

Note 1: *Conductor sizes specified in IEC publications are not recognized in the CE Code, Part I, NEC, or NOM-001-SEDE; however, these can be required for wires and cables intended for use outside of the codes. Information on these metric conductors is given in Annex E.*

Note 2: *Conductor sizes for rope lay stranded flexible conductors specified for transportation, ships, rail and the like are not recognized for these applications in the CE Code, Part I, NEC, or NOM-001-SEDE. Information on these conductors is given in Annex F.*

4.1.5.2 Stranding

The number of strands in the conductors shall be in accordance with Table 3.

4.1.5.3 Concentric

Concentric conductors shall be a round conductor consisting of a round central core surrounded by one or more layers of helically laid round wires all having the same diameter.

4.1.5.4 Compact

A compact-stranded conductor shall be a round conductor consisting of a central core surrounded by one or more helically laid wires, and formed into a smooth outermost layer by rolling, drawing, or other means. The lay length of every layer shall not be less than 8 times nor more than 16 times the outside diameter of the completed conductor except that, for sizes 33.6 mm^2 (2 AWG) and smaller, the maximum lay length shall be 17.5 times the outside diameter. The direction of lay of the outermost layer shall be left-hand, and it shall be reversed or unidirectional/unilay in successive layers.

4.1.5.5 Compressed

A compressed-stranded conductor shall be a round conductor consisting of a central core surrounded by one or more layers of helically laid wires with either the direction of lay reversed in successive layers or unilay or unidirectional lay. The direction of lay of the outer layer shall be left-hand in all cases. The strands of one or more layers shall be slightly compressed by rolling, drawing, or other means to change the originally round strands to various shapes that achieve filling of some of the spaces originally present between the strands.

4.1.5.6 Assembly of strands

A 19-wire combination round-wire unilay stranded conductor shall be round and shall consist of a straight central wire, an inner layer of six wires of the same diameter as the central wire, and an outer layer consisting of six wires with the same diameter as the central wire, alternated with six wires with a diameter of 0.732 times the diameter of the central wire. No particular assembly of the individual wires of any other stranded conductor is required. However, simple bunching (untwisted strands) shall not be used. The length of lay of the strands in a bunch-stranded conductor twisted as a single bunch shall not be greater than indicated in Table 4. The direction of lay of the strands in a bunch-stranded conductor shall be left-hand.

4.1.5.7 Length and direction of lay

Every stranded conductor other than a compact-stranded conductor, or a bunch-stranded conductor twisted as a single bunch, shall comply with the following:

a) The direction of lay of the strands, members, or ropes in a 13.3 – 1010 mm^2 (6 AWG – 2000 kcmil) conductor other than a compressed unilay single input wire, combination unilay, or a compressed unilay or compressed unidirectional lay conductor shall be reversed in successive layers. Rope-lay conductors with bunch-stranded or concentric-stranded members shall be either unidirectional or reversed. All unidirectional lays and the outer layer of reversed lays shall be in the left-hand direction.

b) For a bunch-stranded member of a rope-lay-stranded conductor in which the members are formed into rope-stranded components that are then cabled into the final conductor, the length of lay of the individual members within each component shall not be more than 30 times the outside diameter of one of those members.

c) For a concentric-stranded member of a rope-lay-stranded conductor, the length of lay of the individual strands in a member shall be 8 – 16 times the outside diameter of the member. The direction of lay of the strands in each member shall be reversed in successive layers of the member.

d) The length of lay of the strands in both layers of a 19-wire combination round-wire unilay-stranded copper or aluminum conductor shall be 8 – 16 times the outside diameter of the completed conductor. Otherwise, the length of lay of the strands in every layer of a concentric-lay-stranded conductor consisting of fewer than 37 strands shall be 8 – 16 times the outside diameter of the conductor.

e) The length of lay of the strands in the outer two layers of a concentric-lay-stranded conductor consisting of 37 or more strands shall be 8 – 16 times the outside diameter of the conductor.

f) The length of lay of the members or ropes in the outer layer of a rope-lay-stranded conductor shall be 8 – 16 times the outside diameter of that layer.

The length of lay shall be determined in accordance with the test, Length of Lay, in UL 2556, CSA C22.2 No. 2556, or NMX-516-ANCE.

4.1.6 Diameter and cross-sectional area

4.1.6.1 The nominal diameters of solid and stranded conductors are shown in Table 5 – Table 10. There are no diameter requirements for conductor classes not referenced in Table 5 – Table 10. See 5.2 for conductor resistance requirements. The minimum diameter for a stranded conductor is 98 percent of the nominal. The maximum diameter of any conductor is 101 percent of the nominal. Verification of the diameter shall be determined in accordance with the test, Conductor diameter, in UL 2556, CSA C22.2 No. 2556, or NMX-J-066-ANCE.

4.1.6.2 Conductor sizes in mm^2 (AWG/kcmil) covered by this Standard are shown in Table 5. The nominal cross-sectional area of a conductor identified in Table 5 is not a requirement.

4.1.7 Joints

4.1.7.1 A joint (butt splice) where allowed shall be made before or after insulating and prior to further processing. Where joints (butt splices) are made after insulating, the insulation applied over the joint shall be of the same insulation material used throughout the length of the conductor, or of another insulating material that meets or exceeds the electrical, physical, and mechanical requirements of this Standard for the original insulating material.

4.1.7.2 A joint in a solid conductor or in one of the individual wires of a stranded conductor shall neither increase the diameter nor materially decrease the strength of the conductor or the individual wire. Not more than one of the wires in a stranded conductor of 19 wires or less, nor more than one of the wires in any given layer in a stranded conductor of more than 19 wires, shall be joined in any 0.3 m (1 ft) of conductor.

4.1.7.3 In a rope-lay-stranded conductor, which consists of a central core surrounded by one or more layers of stranded members (primary groups), each member shall be considered equivalent to a solid wire, and as such, shall be spliced as a unit. These joints shall not be any closer together than two lay lengths.

4.1.7.4 A joint shall be allowed in a Class B stranded 2.08 mm^2 (14 AWG), 3.31 mm^2 (12 AWG), 5.26 mm^2 (10 AWG), or 8.37 mm^2 (8 AWG) insulated copper conductor intended to be used in a multiple-conductor cable, with an overall covering. The joint (butt splice) shall be made by machine brazing or welding the entire conductor such that the resulting solid section of the stranded conductor is no longer than 13 mm (0.50 in). In addition, the joint shall not increase the diameter of the conductor, there shall be no sharp points, and the distance between joints in a single conductor shall not average less than 1000 m (3280 ft) in any finished length of that single insulated conductor. Insulated conductors with a joint (butt splice) shall not be surface marked with a type designation.

4.1.8 Separator

A separator of suitable material, when present between the conductor and the insulation, shall be of contrasting color to the conductor color, except that clear or green shall not be used. A white colored separator over aluminum complies with this requirement. The separator and the other wire or cable components shall not have any deleterious effect on one another.

4.2 Insulation

4.2.1 General

4.2.1.1 Conductors shall be insulated with one of the thermoset materials shown in 4.2.1.3 and Table 20. The insulation shall comply with all the requirements of this Standard. The insulation shall be applied directly over the conductor or over the separator, if provided, and shall fit tightly thereto. The insulation shall be free from pores, splinters, and other inhomogeneities visible with normal or corrected vision without magnification.

4.2.1.2 The physical properties of the insulation shall comply with Table 11, when determined in accordance with the test, Physical properties (ultimate elongation and tensile strength), in UL 2556, CSA C22.2 No. 2556, or NMX-J-178-ANCE and NMX-J-186-ANCE.

4.2.1.3 The following insulation materials are identified for use in this Standard:

a) XL;

b) EPCV;

c) Composite insulation:

i) Inner – EP, EPCV, silicone, or XL;

ii) Outer – EPCV, XL, CP, or CPE;

d) EP;

e) SBR/IIR/NR;

f) Silicone; and

g) CP, CPE.

See 4.10 for performance requirements for insulation materials other than those identified for use in items (a) – (g).

4.2.2 Repairs

Where a repair is made in the insulation, the insulation applied to the repaired section shall be equivalent to that removed, and the repaired section of the finished conductor shall comply with the same electrical and thickness requirements specified in this Standard.

In Mexico, repairs to finished conductors are not permitted.

4.2.3 Thickness

The minimum average thickness and minimum insulation thickness at any point shall be as shown in Table 12 – Table 19, when measured in accordance with the test, Thickness, as described in UL 2556, CSA C22.2 No. 2556, or NMX-J-177-ANCE.

4.2.4 Centering

The insulated conductor shall have a circular cross-section, with the insulation applied concentrically about the conductor or any separator (making the conductor plus any separator well centered in the insulation), fitting tightly on the conductor or over any separator. If the insulation is applied in more than one layer, adjacent layers shall be vulcanized, cured, or cross-linked into an integral mass, with the layers not separable. This mass shall be taken as a whole for all measurements and tests, with the exception that the thicknesses of the layers of composite insulation shall be measured separately.

4.2.5 Insulation strand penetration (fall-in)

The insulation shall not penetrate the stranded conductor in a manner that would hamper the free stripping of the insulation when tested in accordance with the test, Fall-in of extruded materials, in UL 2556, CSA C22.2 No. 2556, or NMX-J-556-ANCE.

4.3 Jackets or fibrous coverings over single conductors

4.3.1 A single-conductor wire and each conductor of any 2-conductor flat parallel cable, and each conductor of any multiple-conductor cable, shall have a protective covering of fibrous material or a jacket applied over the outer surface of the insulation, in accordance with Table 20. The temperature rating of the jacket shall be the same as that of the insulated conductor. Requirements for protective coverings other than jackets are covered in Annex G of this Standard. Physical property requirements for jackets shall comply with Table 21, when tested in accordance with the test, Physical properties (ultimate elongation and tensile strength), in UL 2556, CSA C22.2 No. 2556, or NMX-J-178-ANCE and NMX-J-186-ANCE. Jacket thickness requirements are shown in Table 22 – Table 24.

4.3.2 The following materials are identified for use as jackets or coverings:

a) Rubber-filled woven cotton tape;

b) Polypropylene tape under a fibrous wrap or braid;

c) Oriented polyethylene terephthalate tape under a fibrous wrap or braid;

d) Fibrous braid;

e) Fibrous wrap;

f) Neoprene jacket;

g) NBR/PVC jacket;

h) CPE jacket;

i) CP jacket;

j) PVC jacket; and

k) XL jacket.